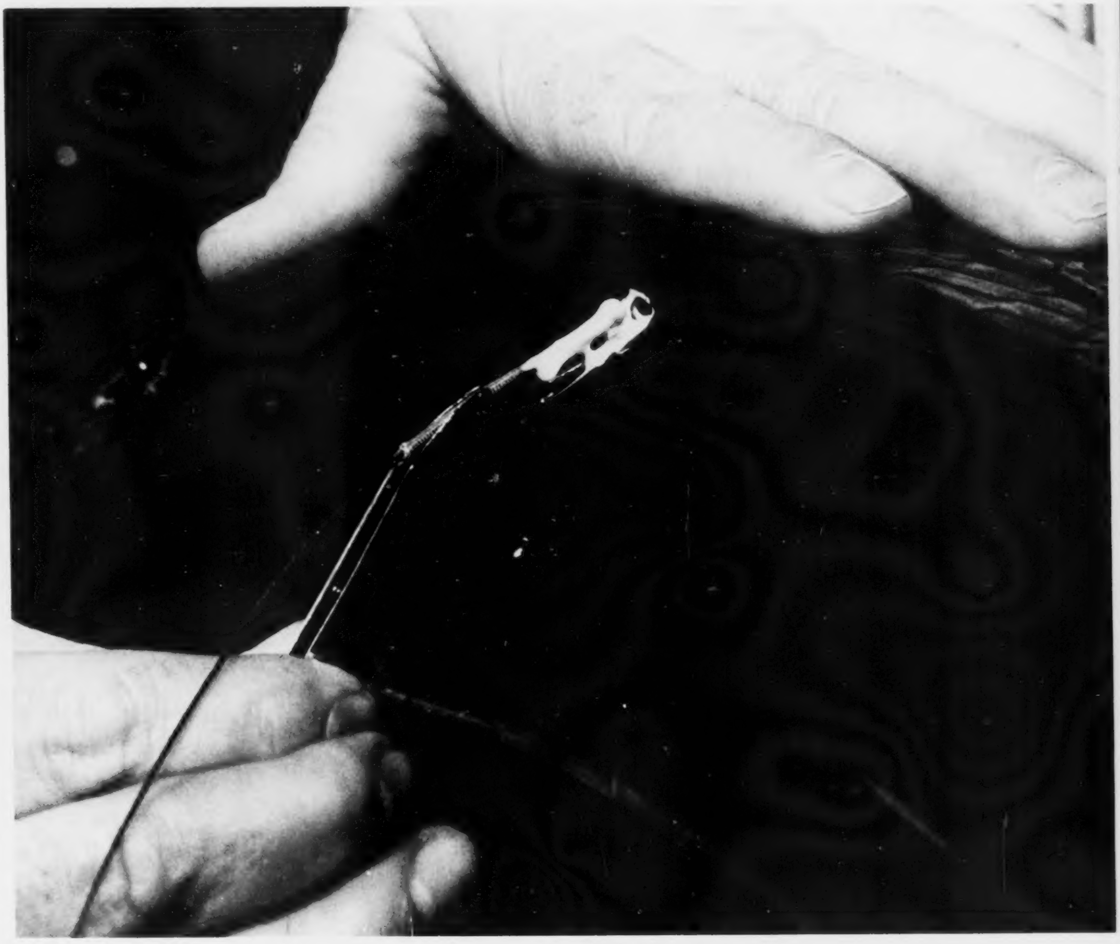
NATIONAL BUREAU OF STANDARDS

June/1968

Technical News Bulletin



U.S. DEPARTMENT OF COMMERCE

NATIONAL BUREAU OF STANDARDS

Technical News Bulletin

JUNE 1968/VOL. 52, NO. 6/ISSUED MONTHLY

U.S. DEPARTMENT OF COMMERCE
C. R. Smith, Secretary

NATIONAL BUREAU OF STANDARDS
A. V. Astin, Director

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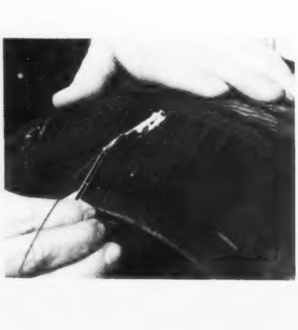

COVER

A thermistor is inserted into a test tire so that the temperature of the running tire may be measured. Tire temperature is then related to tire durability and performance. (See page 119.)

Prepared by the NBS Office of Technical Information and Publications, Washington, D.C. 20234
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The National Bureau of Standards serves as a focal point in the Federal Government for assuring maximum application of the physical and engineering sciences to the advancement of technology in industry and commerce. For this purpose, the Bureau is organized into three institutes—

- The Institute for Basic Standards
- The Institute for Materials Research
- The Institute for Applied Technology

The TECHNICAL NEWS BULLETIN is published to keep science and industry informed regarding the technical programs, accomplishments, and activities of all three institutes.

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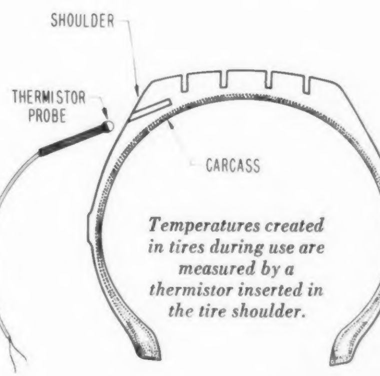
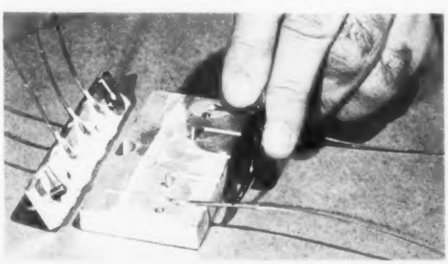
Left: Glenn Ludwig adjusts antenna for picking up the signal from the transmitter mounted over the hub. Above: Glenn Ludwig drills a hole into the shoulder of a tire. The positioning jig and the stop on the shank of the drill permit thermistors to be positioned accurately and identically in all tires.

THERMISTOR TAKES TEMPERATURE OF RUNNING TIRE



Temperatures created in tires during use are measured by a thermistor inserted in the tire shoulder.

An epoxy encapsulated thermistor is removed from the mold after curing; the epoxy forms a sphere around the device and runs partway up its leads.



Capsule Protects Against Shock and Flexing

■ At the NBS Institute for Applied Technology, thermistors embedded in tires to measure their internal temperature in running tests are encapsulated in epoxy for protection. This method of safeguarding the tiny devices from shock, crushing, and flexing was developed by Glenn Ludwig and Dallas Rhodes, of the Bureau's Office of Vehicle Systems Research (OVSR), in work directed by test development engineer Bert Simson.

The tire temperature instrumentation is used to study tire performance under an automobile safety program being conducted by the OVSR for the Department of Transportation's National Highway Safety Bureau.[1] The program also includes studies of occupant restraint systems (such as seat belts) and automotive braking systems.

Heat, the enemy of rubber and fabric, must be measured in tires to study their durability and reliability. This is done by both NBS and tire manufacturers, using several different methods for road and laboratory tests.[2] The Bureau's present instrumentation uses a radio telemetry system, in which the sensor modulates the signal emitted

continued

by a compact radio transmitter mounted on the wheel. The signal picked up by an antenna near the wheel goes to an FM receiver and is then treated by demodulating and conversion circuitry to operate a recorder.

Shortness of sensor life has limited the usefulness of the telemetry system; one tire manufacturer reports typical thermocouple longevities of only 150–400 miles—insufficient to complete measurements on a tire.[3] Still, the less hardy thermistor is often favored for this application despite its short life (typically ended within 150 miles by its leads being torn off)—because of its great output change per degree of temperature shift.

NBS now protects the fragile sensors by sliding a fiberglass sleeve over the leads, daubing the thermistor with epoxy, and allowing it to cure in a split mold holding six of the devices. Closing the mold forces the epoxy into any voids around the thermistors and about half an inch up the leads and sleeves.

Installing Thermistors

Temperature measurements made with the sensors are meaningful only if the sensor is always positioned in exactly the same place within each tire. This is done by inserting it in a hole drilled for it under the edge of the tread at the shoulder of the tire, where the tire is thickest and generates the most heat.

The holes are made uniformly by drilling each through a positioning jig placed on the tread and to a depth controlled by a stop on the drill shank. A separate jig must be made for each tire size and tread pattern by molding it in place on the tread. When the jig is cured a hole is drilled through it to emerge at the desired point and with the desired slant; the hole is lined with metal tubing accommodating the drill size desired.

The encapsulated thermistor is installed by smearing it with a silicon rubber paste that cures at room temperature and inserting it into a hole which has been partially filled with the rubber compound. This forces some of the compound out in a mound, which after curing offers flexible support for the leads. Good results have been obtained by this method; its users are experimenting also with an epoxy emplacement compound that remains deformable after curing.

Findings

Protected thermistors have been used in testing several tires, with no thermistor failures to date. This protection and application technique has enabled the OVSR to run tires on a test wheel, causing the tires to flex even more severely than on a road surface, for up to 4000 miles without interruption for sensor replacement. The OVSR is planning to monitor dynamic temperatures of tires on both the test wheel and on the road in order to gain a better understanding of tire endurance tests.

Measuring Tire Temperature

Several methods of measuring tire temperature have been used in the past. One is to stop the vehicle (or test machine) and insert a thermocouple into the desired position in the tire by means of a hypodermic needle. This method obviously suffers from the change in temperature by the time the measurement can be made, error due to heat conductivity of the probe, and imprecision in positioning the probe. Other methods permit measuring temperatures during use by bringing sensor leads out through the valve and transferring the signal from the turning wheel by means of slip rings and brushes.[2]

More recently the compactness and low power requirements of transistorized circuitry have made it possible to replace mechanical commutators with telemetering transmitters mounted on the wheel. The transmitter receives its signal from a sensor in the tire via leads running outside the tire or, if from a sensor within the tire cavity, via leads passed out through the valve or a feed-through in the rim. The sensor modulates the transmitter's low-powered signal, which is picked up by an associated antenna nearby.

Telemetry Package

Encapsulated thermistors are being used at the National Bureau of Standards in conjunction with a wheel-mounted telemetering package, consisting of a miniaturized modulator and transmitter mounted, with its batteries, on a plate replacing the wheel hubcap. The circuitry used is a modification of that used and shared with the Bureau by a major tire manufacturer. The thermistor resistance controls the frequency of a relaxation oscillator which modulates the transmitter frequency, nominally 104 MHz. As fabricated and packaged at the Bureau, the entire unit occupies a volume about the same as a deck of cards.

The signal from a tire being tested in the laboratory is picked up by a nearby antenna, while that from a tire tested in use on a car is picked up by a loop antenna mounted in the fender wheel cutout. The signal is fed to an FM tuner in the laboratory or in the car, where it is demodulated to produce a signal of frequency identical to that of the relaxation oscillator. Other circuitry converts this cyclic signal to a direct voltage which is recorded on a strip-chart on which are marks from calibration temperatures. All this circuitry is contained in a small rack which can be carried inside the car.

Experimentation and development to improve the sensor-telemetry system are still going on. At present the suitability of thermocouple sensors is being reexamined; their use would make necessary inclusion of a temperature reference junction, but stability would be improved.

[1] **Automotive safety research expanded at NBS,** NBS Tech. News Bull. **51**, 246–248 (Nov. 1967).

[2] **Direct measurement of tire operating temperatures,** NBS Tech. News Bull. **41**, 76–77 (May 1957).

[3] **New approach to tire durability testing,** D. M. Coddington, W. D. Marsh, and H. C. Hodges, Rubber Chem. Technol. **38**, 741–756 (Nov. 1965).

INTERNATIONAL SYSTEM

NBS INTERPRETS POLICY ON SI UNITS

■ In 1964, to facilitate the exchange of scientific information, the National Bureau of Standards adopted* the International System of Units ** (abbreviated SI for Système International) for use by its staff. Since that time it has been the Bureau's policy to employ the SI in all its publications except where the use of these units would obviously impair communication or would reduce the usefulness of a report to its primary recipients.

The Bureau recognized, however, that in adopting the SI a transition period was necessary, so a Units and Usage Committee was appointed to recommend interim practices for the sake of efficient communication by the NBS staff. That committee has explored the problems of transition with scientists at NBS and with outside groups, such as the IEEE Standards Committee, to learn how the transition might best be carried out. The results of the committee's activities are the basis for a detailed interpretation of the NBS policy, which is given below for the benefit of others who also face problems of transition to the SI. It should be kept in mind that these interpretations relate only to the transition period; it is not the Bureau's intention that its staff should use the allowed exceptions to the SI as a basis for perpetuating non-SI usages.

STATEMENT OF POLICY

Numerical data are used in NBS publications in two distinct ways, as descriptive data and as essential data. NBS policy for the transition period accepts different treatment of these two classes of data, although they may be presented in the same text, each with appropriate units. For example, it is acceptable to write "the interferometer mirror mounted on 1-inch rod, was advanced in 10-nanometer increments," or "a 200-inch telescope of 0.497 meter effective aperture."

Descriptive data describe arrangements, environments, noncritical dimensions and shapes of apparatus, and similar measurements not entering into calculations or expression of results.

Essential data express, lead up to, or help to interpret the quantitative results of the activity which is being reported.

NBS policy also recognizes that communication of *scientific* results, via scientific papers, calls for more rigorous standards of units usage than does communication of *technological* results in technological papers.

Descriptive Data

Descriptive data should be expressed in the most useful and convenient manner. Forced translation into SI is not required. The units best understood by the expected audience are the most appropriate. Where non-SI units are used, the author may add SI equivalents in parentheses at his own discretion, but usage within a paper should be consistent on this point. Commercial gage designations or other standard nomenclatures, e.g., drill sizes, are acceptable. As SI units become more commonly used for commercial products, use of SI units in descriptive data should conform.

Essential Data

In technological papers the essential data may be expressed in the units customarily used in the relevant field of technology. SI equivalents should be added in parentheses, or in parallel columns in tables. If graphs are used as the primary or sole means of presenting essential data, the coordinates may be divided according to customary usage, but a secondary set of coordinate markings in SI units should be included. The top and right-hand side of the graph are often appropriate for this purpose. If graphs are used only to indicate trends, or as supplements to tables, units customary in the field are adequate without SI translation. NBS authors should, however, use the SI as soon as the level of SI usage in the related field of technology renders it an efficient communication device. Familiarity with SI units (see Sections 1.1 and 1.2 of the Appendix) is recommended to all NBS authors and all NBS staff.

In purely scientific papers, the essential data *shall* be expressed in SI units, or in units approved for use with the SI. The General Conference on Weights and Measures (CGPM) has designated names and symbols

continued

*NBS adopts International System of Units, NBS Tech. News Bull. **48**, 611 (Apr. 1964).

The SI was defined and given official status by the 11th General Conference on Weights and Measures which met in Paris in October 1960. For assistance in converting between U.S. Customary Units and SI units, see **ASTM Metric Practice Guide, NBS Handbook 102, available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (40 cents).

SI UNITS *continued*

for many of the SI units. These and other names and units approved for NBS use but not yet acted upon by the General Conference are given in Sections 1–6 of the Appendix. Values in other units may be added, in parentheses, where it is felt that this will improve the communication between authors and readers.

Reference data used generally in both science and technology should be expressed in SI units with appropriate indication of conversion factors into technological units or with parallel columns of converted values. Standard reference data applicable primarily to scientific interests (e.g., tables of x-ray atomic energy levels) should be expressed in SI units. Non-SI units may be included as parallel entries.

Where the general usage in any field does not recognize SI units, NBS authors should employ units comprehensible to their readers, but should try to increase reader familiarity with SI units as rapidly as possible. Again, the device of parallel columns (familiar plus SI units) is recommended.

In the lists in the Appendix, the short names for compound units, such as "coulomb" for "ampere-second," exist for convenience, and their use is not compulsory. For example, communication sometimes benefits if the author expresses magnetic flux in volt-seconds, instead of using the synonym, webers, because of the descriptive value implicit in the former unit phrase.

The analysis, interpretation, or application of essential data may involve angles and the related values of natural functions (sine, tangent, log sin, etc.). In these cases, the angles may be expressed in degrees rather than in radians.

APPENDIX

Sections 1–6 present those units which should be used by authors of *scientific* papers for *essential* data. Section 7 presents units which should *not* be used by authors of scientific papers for essential data. Authors of *technological* papers are urged to become familiar with these guidelines, and to follow them as soon as their intended readers are ready to accept and understand them.

1.1 Official SI unit names and symbols:

Unit	Symbol	Unit	Symbol
meter	m	watt	W
kilogram	kg	coulomb	C
second	s	volt	V
ampere	A	ohm	Ω
kelvin [1]	K	farad	F
candela	cd	weber	Wb
radian	rad	henry	H
steradian	sr	tesla	T
hertz	Hz	lumen	lm
newton	N	lux	lx
joule	J		

1.2 Additional names and symbols approved for NBS use:

curie [2]	Ci
degree Celsius [3]	°C
gram	g
mho	mho
mole	mol
siemens [4]	S

1.3 Official prefixes indicating decimal multiples and submultiples:

Multiples and Submultiples	Prefix	Symbol
10^{12}	tera	T
10^{9}	giga	G
10^{6}	mega	M
10^{3}	kilo	k
10^{2}	hecto	h
10	deka	da
10^{-1}	deci	d
10^{-2}	centi	c
10^{-3}	milli	m
10^{-6}	micro	μ
10^{-9}	nano	n
10^{-12}	pico	p
10^{-15}	femto	f
10^{-18}	atto	a

Note: Compound prefixes (e.g., millimicro) are not to be used.

2. Decimal multiples of SI units, bearing coined names, acceptable in their special fields only.[5] Use of SI units, however, is recommended. Examples include:

Unit	Symbol	SI equivalent
angstrom	Å	$=10^{-10}$ m
bar	bar	$=10^{5}$ N/m^2
barn	b	$=10^{-28}$ m^2
kayser [6]	K	$=$cm$^{-1}=100$ m^{-1}
liter [7]	*l*	$=10^{-3}$ m^3
poise	P	$=10^{-1}$ N·s/m^2
rad	rd	$=10^{-2}$ J/kg
stokes	St	$=10^{-4}$ m^2/s

3. "Natural" units.

"Natural" units are acceptable. These are units tied directly to the fundamental Lorentz invariant constants of nature as well as the properties of the microscopic constituents of matter. While it is recognized that in casual conversation, dimensionally incorrect units are used, dimensionally correct units shall be used in published work. (Examples of conversational "shorthand" include: temperature in eV, mass in eV, momentum in fm^{-1}. These usages arise in expressing quantities by the value of *related* quantities: e.g., energy of a particle, wavenumber associated with momentum.) Acceptable "natural" units include:

electronic charge	e
electron mass	m_e
proton mass	m_p
speed of light	c
electron-volt	eV
Planck's constant	h or $\hbar$
Bohr radius	a_0
Bohr magneton	μ_B
nuclear magneton	μ_N
electron radius	r_e
Compton wavelength of electron	λ_C
atomic mass unit	u
Faraday	F

3a. The term "X-unit" is ambiguous, differing in American and European usage. It is acceptable, *provided* that its use is accompanied by its definition in terms of the Kα line of

molybdenum or of tungsten. When accurate conversions to the SI become available, the usage of "X-unit" should be discontinued.

4. Special cgs-esu multiple, acceptable pending CGPM naming of a suitable replacement:

 debye (10^{-18} statcoulomb-centimeter) $= 3.33564 \times 10^{-30}$ coulomb-meter

5. Acceptable logarithmic measures:

 pH
 decibel (dB)
 neper (Np)

6. Acceptable units for essential data in expression of angles in relation to their natural functions, and for naturally occurring geometrical relationships:

degree	$^\circ$
minute	$'$
second	$''$

7. Units *NOT* acceptable for expressing essential data in scientific papers (see **Comments** below):

7.1 Unnecessary coined names:
 gamma (for nanotesla)
 gamma (for microgram)
 fermi (for femtometer, fm)

7.2 Coined names for cgs units (and therefore not compatible with SI):
 gauss
 erg
 dyne
 gal
 stilb

7.3 Units not compatible with the SI, nor any other metric system:
 calorie
 British thermal unit
 entropy unit
 roentgen
 atmosphere
 torr
 millimeter of mercury
 hour (time)[8]
 minute (time and angle)[8, 9]
 degree (angle)[9]
 second (angle)[9]

Comments

The CGPM has not yet adopted a unit for "quantity of matter." Other organizations (ISO and IUPAC) have adopted a mole based on 0.012 kg of carbon twelve; this is equivalent to the familiar gram mole (symbol mol).

USASI and international usage requires that letter symbols deriving from proper names shall be capitalized, although the unit names themselves are lower case.

"Mho" and "siemens" are widely used coined names of derived SI units to which no name has yet been assigned by CGPM. They are, therefore, acceptable until CGPM acts to assign names.

The name "nit" (symbol nt) has been recommended by the International Commission on Illumination for the SI unit of luminance, "candela per square meter" (symbol cd/m^2). Although the name "nit" has not been assigned by CGPM and has not received extensive use, it may be used where the official name is felt to be awkward.

"Poise" and "stokes" are coined cgs names; there are no short names in use for the SI units of "viscosity" and "kinematic viscosity". (The compound names "newton-second per square meter" and "kilogram per meter-second" are long and awkward; a coined short name is needed. "Square meter per second" is also sometimes considered awkward.)

The lists of approved units given in Sections 1–6 are not closed-ended. Other units *compatible with the SI* can and will be added on the basis of:

a) actions taken by subsequent General Conferences;
b) clear indication of need in specialized fields, following approval of the NBS Editorial Review Boards and the NBS Units and Usage Committee.

Artificial creations such as kiloangstrom and cubic angstrom are, for the most part, unnecessary and do more harm than good. They should be replaced by SI units as rapidly as possible.

Certain units based on natural constants, e.g., electron-volt, are both meaningful and convenient. These "natural units" are orders of magnitude outside the range of SI units with prefix.

Most tables of natural functions of angles give the angle in degrees, minutes, and seconds, or in degrees and decimals. Wherever the mathematical or expository treatment or application of essential data require that an angle and its natural functions be related, degrees may be used for expressing the angle. Likewise, wherever naturally occurring geometrical phenomena (crystal data, bond angles, declination of the sun, etc.) are expressed quantitatively, degrees may be used.

The units in 7.3 are convenient and acceptable for descriptive use, but NOT for essential data. For example, the torr is widely used for describing an environment that does not enter into the calculation.

The transition from calories and kilocalories to joules will of course involve some distress. NBS authors are urged to recognize their responsibilities for taking the lead in the acceptance of the joule, while still providing convenient communication to users, by parenthetical equivalents or parallel columns.

The use of "cycles per second" in place of hertz is deprecated. It tends to perpetuate the common misuse of cycle by itself for the frequency unit. When cycle is correctly used by itself, in the same paper as cycles per second, journal editors are prone to "correct" it!

Self-explanatory combinations of prefixed units are acceptable, e.g., milliampere per square centimeter, cubic decimeter, milligram.

The inclusion of the prefix "kilo" in the name of the base unit of mass creates an awkward situation. Logically, the "gram" should be called the "millikilogram"! On recommendation of the International Committee on Weights and Measures, the names of multiples of the kilogram are formed by adding prefixes to the word "gram."

Expression of extended time intervals (essential data) may sometimes be more readily comprehended if

continued

years, hours, and minutes are given in parentheses, as well as, e.g., kiloseconds. However, as the author will recognize, this usage borders on descriptive data. In any case, computations will always require use of seconds only.

Editorial Notes

Words and symbols should NOT be mixed; if mathematical operations are indicated, only symbols should be used. For example, one may write "joules per mole", "J/mol", "J·mol^{-1}", but *not* "joules/mole", "joules mol^{-1}", etc.

Note that exponents operate also on prefixes, as in cm^2, mm^3 which are *not* 10^{-2}m^2, 10^{-3}m^3.

In combinations such as meter-kelvin, use of the product dot (m·K) avoids confusion with "millikelvin". It is good practice to indicate *all* unit products with multiplication dots, since some unit symbols consist of more than one letter, e.g., Wb for weber, *versus* W·b for "watt-barn".

When a compound unit is formed by division of one unit by another, its symbol consists of the symbols for the separate units either separated by a solidus or multiplied by using negative powers (for example, m/s or m·s^{-1} for meter per second). In simple cases use of the solidus is preferred, but in no case should more than one solidus be included in a combination unless parentheses are inserted to avoid ambiguity. In complicated cases, negative powers should be used.

[1] The same name and symbol are used for thermodynamic temperature and temperature interval. (Adopted by the 13th General Conference on Weights and Measures, 1967.)

[2] Accepted by the General Conference on Weights and Measures for use with the SI.

[3] For expressing "Celsius temperature"; may also be used for a temperature interval.

[4] Adopted by IEC and ISO.

[5] The 13th General Conference cancelled the name "micron" and its old symbol, μ; use "micrometer", μm.

[6] Note the conflict with K for kelvin, which is an official symbol. It is felt that context will preclude confusion.

[7] To be used only for expressing volumes of gases and liquids, otherwise use cubic meter, etc.

[8] Allowable when necessary for expression of extended time intervals.

[9] See Section 6 for acceptable use.

ACCURATE MEANS OF MEASURING RF POWER DEVELOPED

■ The measurement of power is fundamental to the electronics industry and is necessary in determining the absolute level of electromagnetic energy. With the effort now being put into space exploration and the rapid rate at which the electronics industry is progressing, greater demands are being made for increased accuracy in the measurement of rf quantities. In rf power measurements, for example, one percent uncertainty is often required for measurements in industrial standards laboratories. Because uncertainties are accumulated in a chain of calibrations, the uncertainties in the reference standards maintained by the National Bureau of Standards must be appreciably less than one percent. Research at the NBS Institute for Basic Standards to meet these demands has resulted in the development of a new dual dry-load calorimeter, which incorporates an automatically controlled reference d-c input power, as an accurate means of measuring rf power.

The new calorimeter, developed by M. L. Crawford of the NBS Radio Standards Laboratory, is a significant advance over existing types in that it provides a power range of 10 mW to 1 W at a working frequency up to 4 GHz with a maximum uncertainty of less than 0.35 percent. The calorimeter represents the following improvements over previous power measuring standards: (1) The power measurement range has been extended down from 50 mW to 10 mW, making possible the direct calibration of 10 mW bolometer mounts; (2) the time required for making a measurement is much less (two minutes as compared to thirty minutes), thus making possible the use of the new calorimeter as a working standard; and (3) automatic digital readout and recording equipment can now be used

for measuring and recording the measured power level.

Many techniques have been employed in establishing accurate rf power standards. Of all the different methods, the calorimetric principle appears to be the most accurate. The technique developed at NBS utilizes the calorimetric principle, coupled with the latest in automatic feedback control equipment and design, to provide the improvements listed above.

Calorimeters

The calorimetric principle is based upon the first law of thermodynamics (the conservation of energy). The measurement of electrical power using this principle depends upon the complete conversion into thermal energy of the electrical energy as delivered by a generator into a resistive load. The heat generated in a load results in a temperature rise in the load and its surroundings. This temperature rise is a function of the input power level and can be detected, for example, with a thermopile located between the load and a reference body whose temperature is stable with time.

Various approaches to the use of calorimetry have been made in the design of rf power standards. These approaches are one of two types: (1) The absolute calorimeter type and (2) the substitution calorimeter type. Both calorimeter types have been built utilizing either dry-load type or flow type terminations. Dry-load, absolute calorimeters are not common because of the difficulty in evaluating them in terms of their thermodynamic properties. Hence, nearly all dry-load calorimeters are used as substitution devices in which the calorimeter response to rf is equated to its response to a reference d-c power. This is called the rf to d-c substitution principle.

The substitution principle in calorimetry is based upon the assumption that heat generated by d-c power absorbed by a load will have the same effect on the device used to sense the temperature rise of the load as would heat generated by an equal amount of rf power. In general, however, equal quantities of rf and d-c power will not produce exactly the same calorimeter sensor response. Thus, an error, commonly called the rf to d-c substitution error, exists and must be evaluated to determine the uncertainty in the power measurement.

The main problems associated with measuring power using the substitution calorimetric method are: (1) The lengthy time required for the system to reach equilibrium, (2) the difficulty in maintaining a constant, stable thermal environment during the measurement period, (3) the need for extremely stable rf sources to maintain a constant input power during the length measurement period, and (4) the difficulty in evaluating the rf to d-c substitution error. Various approaches have been made to reduce these problems and to improve the substitution calorimeter.

M. L. Crawford uses a newly developed dual dry-load calorimeter to accurately measure rf power.

System Description

The present approach, which is suitable for low power levels, is a dual dry-load arrangement combined with a differential thermopile between the loads. The thermopile output is proportional to the temperature differential between the loads. This output is then used as an error signal for a feedback control system which adjusts the power input into one of the loads, thereby tending to eliminate the error signal. This has the advantage of automatically adjusting the power level in the reference load almost simultaneously with changes in input power to the measuring load. Thus, the time required for the measurement is greatly reduced.

The NBS power measuring system consists of two nearly identical, 50-ohm loads mounted symmetrically in a common temperature-controlled environment, a differential thermopile installed between the loads, a d-c operational amplifier, a floating power supply, a compensation system, and a d-c power amplifier with output current- and voltage-measuring equipment. The two loads are precision coaxial loads with 14-mm connectors. The thermopile is composed of 50 junctions of five-mil copper and constantan wire. A portion of the control system, along with the two loads and the thermopile, are enclosed in a shielded, sealed copper box, which is immersed in a temperature-controlled (± 0.002 deg C) oil bath. The copper box shields the thermopile output from spurious signals.

System measurement uncertainties are less than ± 0.26 percent in the 0–1 GHz frequency range and less than ± 0.35 percent in the 1–4 GHz frequency range.

298-794 O - 68 - 2

PROGRESS MADE IN FAIR PACKAGING PROGRAM

Under FPLA, manufacturer and net quantity of contents must be uniformly and prominently displayed on a package. Quantity must be in ounces when under four pounds and displayed on the lower third of the label.

NBS Gets Industry Cooperation

■ The buyer of packaged products in retail stores often faces a difficult task in deciding which package size will give him the most for his money. He may be offered, for example, 4⅜ ounces of a product for 32 cents, or the same product at 5 ounces for 36 cents under a different brand name. A recent survey showed that he may be offered as many as 23 specific sizes of cereal, 28 separate sizes of dry detergents, and 26 unique sizes of toothpastes—*all in a single retail store.* Without pencil and paper, and some facility with fractions and long division, he has little chance of selecting the best value.

It now appears, however, that he may soon find his problem greatly simplified. Recently the National Coffee Manufacturers Association informed the National Bureau of Standards that the industry was eliminating all sizes of packaged soluble coffee except even ounces between 2 and 16 ounces. The Institute of Shortening and Edible Oils has also reported that its members are reducing the quantities in which its products are packaged from 15 to 7. Meanwhile, at least 30 other groups are in various stages of feasibility studies to determine the need for or the best approach to such action.

These voluntary efforts to help the consumer result directly from an intensive program of information and education which the National Bureau of Standards has been conducting among various segments of industry. The Bureau has been given the job of carrying out the responsibilities assigned to the Secretary of Commerce under the Fair Packaging and Labeling Act (FPLA) of 1966 (Public Law 89–755). The Act requires the Secretary of Commerce to determine whether the number of quantities in which any given commodity is packaged has proliferated to the extent that consumers cannot make effective comparisons and value judgments. Where a determination of "undue proliferation" has been made, the Secretary must request manufacturers, packagers, and distributors to participate in the development of a voluntary Product Standard under the Bureau's voluntary standards program. NBS work in carrying out the provisions of FPLA is under the general direction of M. W. Jensen, NBS Manager of Engineering Standards.

Proposed procedures for formal determination of "undue proliferation" have been developed by NBS and published in the *Federal Register.* These procedures include (1) developing information on the existence of possible undue proliferation, (2) conducting an inquiry, (3) publishing in the *Federal Register* a proposed determination of undue proliferation, (4) receiving and analyzing comments and, if requested, holding an oral hearing, (5) determining whether undue proliferation does exist, (6) publishing in the *Federal Register* the determination, and (7) issuing a request to industry to participate in the development of a voluntary standard if undue proliferation has been determined. Section 5 of the Act provides that Congress be informed if a voluntary Product Standard cannot be agreed upon, under the consensus principle, within one year after an official request is issued to industry. If a standard is published and is not being observed, Congress must also be informed.

Although the Act provides for formal determination and announcement of undue proliferation by these procedures, it was felt that voluntary acknowledgment and action by industry should be encouraged wherever possible. In this way undue proliferation could be eliminated much more rapidly and with less disturbance of the market and of industry-Government relations. Voluntary action is also likely to be more universal throughout an industry.

NBS therefore began a broad effort to acquaint industry leaders with the new law and its implications and with the principle and application of the voluntary standards process. NBS staff members have arranged and conducted 16 seminars for industry and trade association executives and have made more than 50 formal presentations to industry groups on the subjects of FPLA and the voluntary product standards process. In addition, at least 60 private conferences with packagers, wholesalers, and retailers have been held.

While these information and education programs were underway, NBS staff members have been planning and conducting product surveys. Commodities to be surveyed were chosen from those discussed during the congressional hearings on the Act and those recommended by State and local weights and measures officials. Studies have now been completed, or are nearing completion, on more than 75 different items. These studies involve visits to retail outlets throughout the Nation and the collection and tabu-

lation of full labeling and pricing data on commodities offered for sale. More than 1000 retail stores have been visited by NBS staff members or cooperating State and local weights and measures officials. When a nationwide product survey is made, nine major geographic regions of the United States are covered, with at least one State in each region included.

Whenever the tabulated data on a particular commodity indicate a reasonable possibility of undue proliferation, the trade organization representing the packagers of that product is asked to select an appropriate group to meet with NBS officials to discuss the data, the voluntary standards process, and a course of action to follow. Action at the initiative of industry is always recommended. Conferences with top corporation executives have also been held, some at NBS instigation, some at the request of the corporations. Attempts have been made to select those corporations with broad and influential lines in the consumer area. These conferences have proved quite effective.

As a result of these efforts, a number of trade organizations representing packagers have met or are meeting to decide whether to proceed with a voluntary standard for reduction of the packaged quantities offered for sale. In some cases decisions have already been made to develop voluntary standards through Department of Commerce procedures administered by NBS. A summary of the activity in various industry areas is given below.

Dry Breakfast Cereals—The Cereal Institute is working to determine whether to proceed themselves or through Commerce Department procedures in the reduction of the quantities in which dry breakfast cereals are offered.

Detergents—The Soap and Detergent Association has requested the development of a voluntary Product Standard under Commerce procedures covering the quantities in which heavy-duty normal density detergent is marketed. They are also conducting studies in the areas of liquid detergents and liquid household cleaners to determine their future course of action.

Paper Towels in Rolls—A special committee of the American Paper Institute has been appointed and is working with NBS. The problem has been defined and several possible solutions have been developed.

Potato Chips—The Potato Chip Institute International has developed recommendations for its members to reduce the number of package sizes in which this product is offered for sale.

Toothpaste—The Toilet Goods Association has requested NBS to assist in the development of a voluntary Product Standard covering the quantities in which toothpaste in tubes is offered for sale.

Macaroni—The Macaroni Manufacturers Association has appointed a committee to determine the best method to solve what appears to be a proliferation problem.

Instant Potatoes—The Instant Potato Products Association has requested NBS to assist in the development of a voluntary Product Standard.

Jellies and Jams—The National Preservers Association is conducting a nationwide survey at the request of NBS.

Cheese—The National Cheese Institute has formed a committee to determine the extent of proliferation in packaged cheese.

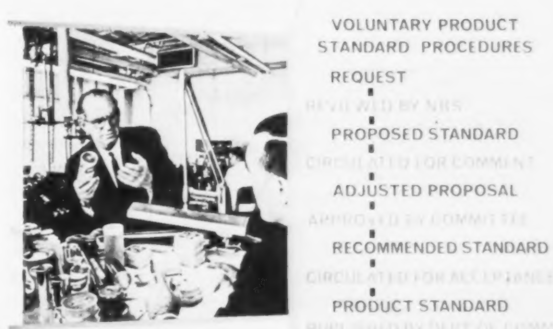
Peanut Butter—Representatives of the industry have informed NBS that they are exploring the possibility of requesting a voluntary Product Standard.

Mayonnaise and Salad Dressings—The Mayonnaise and Salad Dressings Institute is conducting a nationwide survey at the request of NBS.

Uniformity in Labeling

An important objective of the new law is nationwide uniformity in such consumer package labeling as will
continued on page 135

Determining undue proliferation (top) and assisting industry groups in arriving at voluntary standards (bottom) are the main responsibilities that NBS administers for the Department of Commerce under the Fair Packaging and Labeling Act.



D. G. Goebel measures the reflectance of a reflectance standard with a goniophotometer.

ALMOST EVERYONE is influenced daily by his perception of color, whether in selecting articles of clothing or furniture that harmonize, or in the more serious matter of correctly interpreting the colors of traffic lights and signs. Color has thus come to play an important role in the production and distribution of goods in our economy. Obviously paints, dyes, inks, and cosmetics must be manufactured to meet rigorous color specifications. But the manufacturers of automobiles, kitchenware, household appliances, television sets, office equipment, foods, drugs, and numerous other products must also pay careful attention to color. Millions of dollars are spent each day on meat and produce selected largely on the basis of color, and great quantities of petroleum products are classified and sold by their color. Many persons, such as industrial designers, interior decorators, artists, and photographers, are concerned with problems of color during a large part of their working day.

This broad dependence on color in industry and commerce has brought with it a need for accurate means of specifying and comparing colors, based on color standards and precise methods of color measurement.[1] Much of the research that today makes possible the accurate designation of colors throughout science and industry has been carried on at the National Bureau of Standards.

NBS began research on color as early as 1912. At that time representatives from a cottonseed oil firm and the butter and oleomargarine industries called on the Bureau for help with the color grading of their products. In a matter of several years, color problems collected in Bureau correspondence ranged from those of glass in signal lights, headlights, and spectacles for eye protection to color problems in petroleum, turpentine, rosin, paper, textiles, flour, eggshells, dyes, and numerous other materials. In seeking answers to these color problems, NBS became involved in a wide new area of research.

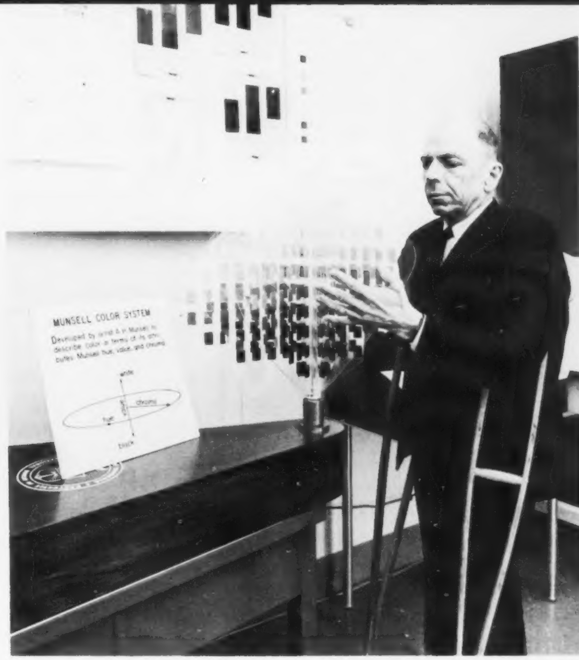
Definition of Color

Some scientists contend that color is a purely physical property of radiant flux, since the spectral power distribution of any light beam (emitted, reflected, or transmitted) may be measured with a spectroradiometer, and since spectral power distribution is closely related to color. By introducing sodium into the flame of a bunsen burner, however, the flame color can be changed to an orange color which is similar to that of daylight reflected from an orange peel. Nevertheless, the spectral distribution obtained with a spectroradiometer will show that the spectral composition of the light reflected from the orange peel under daylight illumination is radically different from that emitted by the sodium flame. Thus it appears that a purely physical treatment of color is not the most useful.

A widely accepted definition of color is that given by the committee on Colorimetry of the Optical Society of America: "Color consists of the characteristics of light other than spatial and temporal inhomogeneities; light being that aspect of radiant energy of which a human observer is aware through the visual sensations which arise from the stimulation of the retina of the eye." Note that this definition relates color and light to radiant energy only insofar as the energy produces a visual effect within an observer.

Standardization of Color

If an observer with normal color vision attempts to adjust one compo-



Right: K. L. Kelly examines a color solid divided into ten segments, each of which contains chips representing hue, saturation, and lightness. Above: R. E. Brown calibrates filters which will be distributed to other standards laboratories for the calibration of photometers.

nent in his visual field, the color of which is under his control, so that it matches a neighboring color, he will ultimately discover that three independent adjustments have to be made. If he is using the red, yellow, and blue paints frequently found in paint boxes used in primary schools, only by chance will he obtain a match from a mixture of two of them. For example, a brown color requires blue in addition to red and yellow. Within the color gamut of the three paints, an exact match for a given paint color is easily possible, but a minimum of three primary colors is necessary. Similarly, the attempt to color-match one spot of light by shining several spotlights of different colors onto one neighboring spot generally requires a mixture of three lights of fixed spectral composition.

These and other factors resulted in the standardization of color based on three elements: (1) the characteristics of the light source, (2) those of the object (spectral reflectance curve), and (3) those of the observer who is to view the object (specified by three color-matching functions). A major contribution by NBS to this standardization scheme was the experimental determination of the spectral luminous efficiency curve representing the average observer. Assembled data from numerous persons of assorted ages and of both sexes were analyzed to obtain a curve truly typical of human vision.

In 1931 the Commission Internationale de l'Éclairage (CIE) recommended that all subsequent color data be expressed in terms of the same tristimulus (three-primary) system so that the results would be immediately comparable. A standard observer and coordinate system for small fields (2°) were recommended based in part on the above mentioned work performed at the Bureau. This standard observer and coordinate system remain the cornerstone of all photometry and colorimetry to the present day.

In 1964 the CIE recommended a supplementary observer and coordinate system for large fields (10°) based on NBS analysis of British and Russian data. Further NBS analysis of these data resulted in a quantitative measure of the variability of color vision among normal observers.

The CIE system was so formulated that the green primary, designated as Y, carries all of the luminous flux, while the other two primaries (red and blue), designated as X and Z, carry none of the luminous flux. Because the values of Y are obtained by the use of the standard spectral luminous efficiency function $\bar{y}(\lambda)$, it is customary to express the Y value of a luminous area as its luminance (photometric brightness) in terms of candelas per square meter. The Y value of an opaque specimen may be conveniently expressed as its luminous reflectance and the Y value of a transmitting specimen is customarily put in terms of luminous transmittance.

If, as is usual, light combinations or mixtures are not the chief interest, it is convenient to substitute for the tristimulus values, X, Y, Z, the two ratios X (X+Y+Z) and Y (X+Y+Z), combined with Y. The two ratios are known as chromaticity coordinates, x, y, because they serve to specify the chromatic aspect of light. A diagram of the points representing the spectrum colors in x, y is known as a chromaticity diagram.

At the time of setting up the standard observer and coordinate system,

continued

continued

the International Commission on Illumination recommended three standard illuminants for colorimetry, along with standard angular conditions of lighting and viewing, and a reflectance standard for the colorimetry of opaque specimens. The standard illuminants were: illuminant A, representative of gas-filled incandescent lamps; illuminant B, representative of noon sunlight; and illuminant C, representative of average daylight such as that from a completely overcast sky. NBS contributed by supplying the formulation of the filters required for standards B and C.

The specific angular conditions for lighting and viewing when measuring the color of opaque specimens were that the light should strike the specimen at 45° and that the specimen be viewed along the perpendicular to its surface.

The reflectance standard previously recommended and in use for many years for the colorimetry of opaque specimens was a white surface prepared by collecting on a metallic or other suitable surface an opaque layer formed by the smoke from magnesium ribbon or shavings burning in air. The currently recommended reflectance standard is a "perfect diffuser" which would result in the measurements being made on an absolute basis.

It is now common practice to carry out the spectrophotometry of color standards relative to the magnesium oxide standard; that is, the ratio of the spectral reflectance factor of the unknown specimen to that of the magnesium oxide standard is found rather than the absolute value of reflectance factor itself. For the angular conditions of 6° incidence and hemispherical viewing, the absolute reflectance of a magnesium oxide standard is known so that for these geometric conditions the absolute reflectance of the measured color standards can be computed.

Color Instrumentation

Over the years, the spectrophotometer has become the primary tool for color evaluation. It is used at NBS, for example, in calibrating standards of color. In a calibration, the spectral reflectance factor curve of each standard is obtained at intervals of the spectrum (usually 10 nanometers). Taking into account the standard illuminating source, the tristimulus values of the standards may be computed. From the tristimulus values, the chromaticity coordinates (x,y) are then calculated. These values along with the luminous reflectance factor completely characterize the color of the standards. The rather lengthy computations are easily made by use of a computer.

It had been suggested as early as 1928, long before automatic computers, that to avoid lengthy calculations tristimulus colorimetry could be achieved by approximating the CIE functions with source-filter-photocell combinations. For this purpose the Bureau developed in 1942 a photoelectric colorimeter with three filters. Later, in 1954, the approximation to the CIE functions was improved by introducing the use of mosaic filters. Approximate tristimulus values of a sample are found as the outputs of the three filter-photocell combinations on which light from the sample illuminated by the source is permitted to fall. This process is simpler than the spectrophotometric method of color evaluation and is adequate in cases where high accuracy is not essential.

Color and Safety

Color plays an important part in conveying information to the driver of an automobile. NBS research has provided answers to many problems in this area, such as determining the best colors for signs to convey information to both normal-visioned and color-blind drivers. The Bureau did much scientific groundwork upon which is based the signal colors of all of our railroads. The standard colors used in marine navigation, highway traffic-control, and aeronautics are based on work done by the Bureau. NBS scientists participated in the first National Conference on School Bus Standards in 1922 and were instrumental in the early adoption by forty-six states of the color for school buses designated as National School Bus Chrome.

The Bureau also conducted research on color induction in an attempt to increase the efficiency of signs.[2] It had been known for many years that perception of a centrally located color was influenced by a different surrounding color. For instance, a red surround makes a central field appear greener; the converse is also true. The study showed that this influence could be calculated quantitatively. This work provided a means of determining in advance the amount of induction between a central field and a surround, and so made it possible to better design a color scheme.

Color Designation

The most widely used scheme for color designation of material specimens is the Munsell system. The basis of the Munsell system is a description of surface color perceptions in terms of hue, lightness, and saturation. Each such tridimensional description is represented by a point plotted in a space diagram known as a *surface-color solid*. In the surface-color solid the central axis represents the grays extending from black at the bottom to white at the top. *Lightness* of a chromatic (non-gray) color perception determines the gray to which it is equivalent on this scale. Lightness is represented in the color solid by distance above the base plane. *Hue* determines whether a color is perceived as red, yellow, green, blue, purple, or some intermediate; it is represented in the color solid by angle about the central axis. *Saturation* indicates the degree of departure of a

surface-color perception from the gray of the same lightness; it is represented by its distance from the central gray axis.

Over the years, the many branches of art, science, and technology that use color have developed their own characteristic color vocabularies. Some of these vocabularies are very similar—in fact, they borrow from one another—while others, useful in one field, are nearly or completely unintelligible to workers in another field. The color world for many years had needed a dictionary of color names that would correlate the color terms used in different fields and thus provide a common language for scientists, businessmen, and the general public to compare and identify colors.

The National Bureau of Standards in 1955 compiled such a comprehensive dictionary with the cooperation of the Inter-Society Color Council (ISCC). The end result of eight years of research and study, this dictionary not only includes color names from the various fields of application but also relates all the names listed to a common, fundamental system of designation. It lists about 7500 individual color names and defines them in simple, accurate terms that can be easily understood by persons working in different fields. Included in this dictionary are such prosaic color names as "red," "pea green," and "dull reddish yellow," along with more fanciful names as "kitten's ear," "vamp," and "French nude."

Listings are arranged in such a way as to permit translation rapidly and accurately from one color vocabulary to another. For example, the dictionary shows that griseo-viridis (from biology) is equivalent to serpentine (fashion), to mint green (mass market), and finally to light green (ISCC-NBS color designation).[3]

Other Contributions

Another contribution by NBS was the establishment of a scale of color temperature in 1934 based on visual color matches between incandescent lamps and a blackbody at three fixed temperatures, the freezing points of platinum (2042 K), rhodium (2233 K), and iridium (2716 K). This scale replaced that previously used and is still the basis for calibration of incandescent lamps by the Bureau.

In 1939 D. B. Judd of NBS derived a measure of the perceptual sizes of color differences in terms of what has now become known as the NBS unit of color difference.[4] Many commercial products are purchased daily, with color tolerances of about one NBS unit. The Bureau used this unit of color difference in 1957 to improve the spacing of the Union Colorimeter Scale for color grading lubricating oil and petrolatum.[5] The respaced scale was incorporated into ASTM Method D 1500–58T and is currently in force.

Current Projects

All of the problems of color measurement and specification are by no means solved. For example, an investigation is underway to determine the discrimination of colors of targets that have relatively low luminance and small field size. The answer to this problem is vitally important in designing traffic signal systems, aircraft runway markings, and marine navigation beacons.

Another study deals with a determination of constant hue lines. These are lines along which colors, strong or weak, may be said to have the same hue.

Some years ago the CIE recommended the use of a color rendering index to characterize the effectiveness of artificial lights to render colors as if they were illuminated by standard reference sources. While this index was generally useful, it was found that some lights that were scored low by this index were nevertheless rendering some colors, such as flesh tones, in an acceptable or even preferable manner since they tended to flatter the viewed object. NBS scientists started to develop a so-called "flattery index" that is more suited to the lighting of homes, gardens, reception rooms, and restaurants.[6] A preliminary index, which still requires further refinement, has been devised and is serving as a basis for further investigation to help manufacturers design better lighting systems for this aspect of color rendition.

Bureau scientists are continuing to search for answers to many problems of color as seen by the human eye. Studies of metameric pairs, two objects with different spectral characteristics but with the same color under at least one set of illuminating and viewing conditions, are typical. These studies have already given valuable information regarding the response of the average eye and research is continuing in this area. Other studies are being made in the fields of color blindness and color communication and in the use of color in safety engineering.

[1] **Colorimetry,** by I. Nimeroff, NBS Mono. 104 (Nov. 1967). Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for 35 cents.

[2] **Quantitative evaluation of color induction,** NBS Tech. News Bull. 51, No. 11, 215–216 (Oct. 1967).

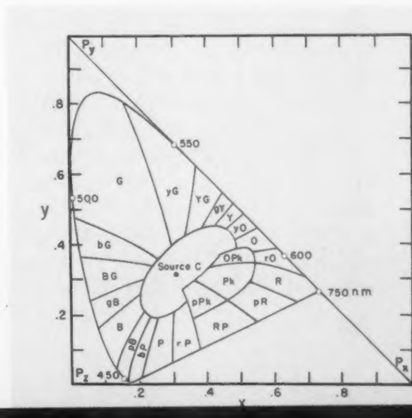
[3] **ISCC–NBS Method of Designating Colors and a Dictionary of Color Names,** by K. L. Kelly and D. B. Judd, NBS Circ. 553 (1955). Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for $2.

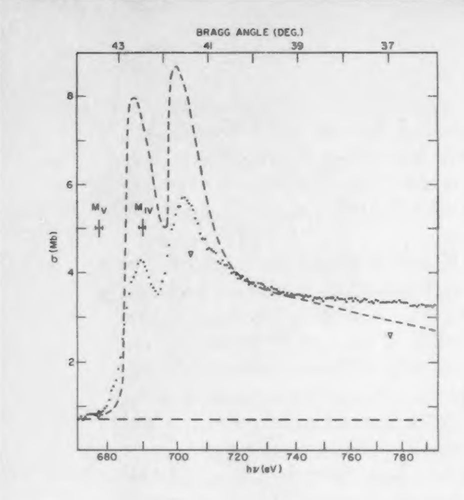
[4] **Specification of color tolerances at the National Bureau of Standards,** by D. B. Judd, Am. J. Psychol. **52**, 408 (1939); see also, **Determination of color differences,** NBS Tech. News Bull. **34**, No. 8, 106 (Aug. 1955).

[5] **New color scale for petroleum products,** NBS Tech. News Bull. **41**, No. 10, 152 (Oct. 1957).

[6] **A flattery index for artificial illuminants,** by D. B. Judd, Illum. Engr. **52**, 593 (1967).

The (x,y)-chromaticity diagram of the ICI system. The abscissa, x, is the ratio of the tristimulus value, X, to the sum of all three primaries (X+Y+Z). The ordinate, y, is the ratio of Y to this sum. The region bounded by the spectrum locus and the straight line 450–470 nm joining its extremes represents all chromaticities producible by actual stimuli.





Above: The computed theoretical cross section (dashed curve) of xenon is compared with the experimentally derived cross section (dotted curve). Cross section (σ) is plotted as a function both of the photon initial energy (hν), and of the angle of deflection of the photon after collision (Bragg angle). Data obtained by previous investigators several years ago (triangles) were never adequately explained until now. Below: S. T. Manson (seated) and J. W. Cooper examine newly plotted photoionization cross sections of xenon. They developed the theoretical basis for calculating improved first approximations of the photoionization cross sections of the elements.

NEW METHOD FOR PHOTOIONIZATION CROSS SECTIONS

■ Scientists at the National Bureau of Standards have developed methods for obtaining the photoionization cross sections of all the elements, using photons of soft (very long wavelength) x rays. The photoionization cross section is a measure of the probability that a photon (in passing through unit length of a volume just sufficient to contain one atom) will undergo a collision with an atom, and cause it to become electrically charged or ionized.

In the course of this work, theory has been developed that now makes it possible to obtain more accurate photoionization cross sections. These results have been applied to obtain data on the absorption spectra of soft x rays, a region of the spectrum that until now has not been extensively explored. Such data can be of great value in studies of atomic structure as well as in research on the solid state structure of matter, the nature of the upper atmosphere, the composition of the sun and stars, and environmental conditions in outer space.

The theoretical basis for calculating improved first approximations of the cross sections was worked out by J. W. Cooper of the NBS Institute for Basic Standards and S. T. Manson,[1] an NRC–NBS Postdoctoral Research Associate at the Institute. Similar work is being carried on by investigators in other laboratories, notably F. Combet-Farnoux and Y. Heno of the Laboratoire De Chimie Physique, Paris, France. Correlative experimental studies have been carried out by R. D. Deslattes,[2] also of the Institute staff.

Until recently, the photoionization cross sections of the elements for the soft x-ray region have been generally based on extrapolation to lower photon energies of the hydrogen-like behavior exhibited by these elements in the ordinary x-ray range. Adequate experimental data on photon absorption in the soft x-ray region have been lacking.

NBS scientists tried a different theoretical approach, using the one-electron model to analyze the structure of the elements, especially the heavier elements. Photoionization cross sections calculated from this model showed large differences from the extrapolated values based on the hydrogen model. These differences seemed to indicate the presence of rather prominent, broad peaks in the soft x-ray range of the absorption spectra of the elements studied. Such maxima were found in the xenon M region by Dr. Deslattes. His experimental measurements were performed with a Bragg double-crystal spectrometer, modified to use only one crystal and a detection system.

Calculations based on this theory have been made for many of the elements of the periodic table. The elements were chosen for their strategic location: rare gases and those elements which exhibit both filled and slightly unfilled "M" and "N" electron orbits. The elements used for the calculations included not only argon, krypton, and xenon—those measured experimentally—but also aluminum, copper, germanium, europium, gold, and fermium.

Hopefully, the photoionization cross section values obtained by NBS workers will assist scientists and engineers by providing calculations of cross sections for other elements, and will provide a check for values previously computed for the elements covered. This method of calculation can be used to compute cross sections to a much better first approximation than has formerly been accomplished.

The results obtained thus far appear to indicate a systematic trend relating photoionization cross section to atomic number and to the internal binding energy of the atom. Further work will have to be done, however, to establish the validity of these relationships.

[1] **Photo-ionization in the soft x-ray range: Z dependence in a central-potential model**, by S. T. Manson and J. W. Cooper, Phys. Rev. **165**, No. 1, 126–138 (Jan. 1968).

[2] **Photoionization of the M-shell of xenon**, by R. D. Deslattes, Phys. Rev. Letters **20**, No. 10, 483 (Mar. 1968).

STANDARDS AND CALIBRATION

STANDARD FREQUENCY AND TIME BROADCASTS

WWV—2.5, 5.0, 10.0, 15.0, 20.0, and 25.0 MHz
WWVH—2.5, 5.0, 10.0, and 15.0 MHz
WWVB—60 kHz

Radio stations WWV (Fort Collins, Colo.) and WWVH (Maui, Hawaii) broadcast signals that are kept in close agreement with the UT2 scale by making step adjustments of 100 ms as necessary. Each pulse indicates that the earth has rotated approximately 15 arcseconds about its axis since the previous one. Adjustments are made at 0000 UT on the first day of a month. *There will be no adjustment made on July 1, 1968.* The pulses occur at intervals that are longer than one second by 300 parts in 10^{10} due to an offset in carrier frequency coordinated by the Bureau International de l'Heure (BIH), Paris, France.

Radio station WWVB (Fort Collins, Colo.), broadcasts seconds pulses derived from the NBS Time Standard (NBS–III) with no offset. Step adjustments of 200 ms are made at 0000 UT on the first day of a month when necessary. BIH announces when such adjustments should be made in the scale to maintain the seconds pulses within about 100 ms of UT2. *There will be no adjustment made on July 1, 1968.*

JILA NAMES VISITING FELLOWS

■ The Joint Instittue for Laboratory Astrophysics (JILA), at the University of Colorado in Boulder, has named 11 scientists as visiting fellows at the University for the 1968–69 academic year.

The visiting fellowship program, supported by a grant from the National Bureau of Standards to the University, is now in its seventh year of bringing outstanding scientists to Boulder for visits of up to one year. The visiting fellows work on research of their own choosing in fields of astrophysics, atomic and chemical physics, aerodynamics, and related areas.

Visiting fellows for the next year are:

Benjamin Benderson, atomic physicist and professor of physics at the Courant Institute for Mathematical Sciences of New York University.

Dudley Herschbach, professor of chemistry, Harvard University, member of the National Academy of Sciences, and expert in chemical kinetics.

Sydney C. Haydon, professor and head of the physics department, University of New England, Armidale, N.S.W., Australia, has worked in atomic and plasma physics.

Bohdan Paczynski, assistant professor of astronomy, Institute of Astronomy, Polish Academy of Sciences, Warsaw, is widely known for his original work in stellar evolution.

Richard Porter, associate professor of chemistry, University of Arkansas, is well known for his contributions to molecular structure.

Lindsey F. Smith, acting assistant professor of astronomy, University of California, Los Angeles, has made extensive studies of unusual types of stars.

Derek N. Stacey, research fellow, St. Catherine's College and Clarendon Laboratory, University of Oxford, is a specialist in optics and spectroscopy.

Pol Swings, professor of astrophysics, University of Liege, Belgium. A former president of the International Astronomical Union, Dr. Swings is a world-renowned laboratory astrophysicist and Director of the Institute for Astrophysics of the University of Liege.

Rafael Valesco, professor of physics and head of the spectroscopy department, University of Madrid.

Marshal H. Wrubel, professor of astronomy, Indiana University, is known for his theoretical studies of model stellar atmospheres.

JILA was organized in 1962 as a collaborative effort of the Bureau and the University for research and advanced training in astrophysics, atomic and chemical physics, aerodynamics and related areas. Thirty-seven graduate students are engaged in research in the Institute for their doctorate degrees from the University. JILA conducts laboratory and theoretical studies to complement results obtained by observational programs at astronomical observatories and space research facilities. Current efforts center on stellar atmospheres and stellar stability, atomic and molecular collisions, spectroscopy, chemical and plasma physics, and optical resonance phenomena.

NSRDS NEWS

This column regularly reports significant developments in the program of the National Standard Reference Data System. The NSRDS was established in 1963 by the President's Office of Science and Technology to make critically evaluated data in the physical sciences available to science and technology on a national basis. The System is administered and coordinated by the National Bureau of Standards through the NBS Office of Standard Reference Data, located in the Administration Building at the NBS Gaithersburg Laboratories.

Supplement to Bibliography on Atomic Transition Probabilities

A supplement to NBS Miscellaneous Publication 278, *Bibliography on Atomic Transition Probabilities*[1] (30 cents), by B. M. Glennon and W. L. Wiese, has recently been published. It covers the literature on this subject from May 1966 through December 1967. Arranged by elements and stages of ionization, each reference indicates the method employed and class of transitions. Only articles on discrete transitions, both allowed and forbidden, are listed. To keep this bibliography at a reasonable size, papers containing data for more than 20 individual elements or stages of ionization are collected separately in front of the list. A selected list of papers dealing with the subject of transition probabilities from a general point of view is also included.

Eighth Conference on Thermal Conductivity

The Thermophysical Properties Research Center, an associated National Standard Reference Data Center, will host the Eighth Conference on Thermal Conductivity at Purdue University, West Lafayette, Ind., Oct. 7–10, 1968. Technical papers are invited on all aspects of thermal transport in solids, liquids, and gases. Conference Chairmen are C. Y. Ho and R. E. Taylor. Those desiring further information should write:

W. H. Shafer
Assistant Director—Technical
Thermal Properties Research Center
West Lafayette, Ind. 47906

How to Order NSRDS and Related NBS Publications

Because a number of persons have written to the Office of Standard Reference Data to ask how to purchase NSRDS and related NBS documents, the details for ordering publications are given here.

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The full letter symbols with each publication number and full title of the publication and author must be given when ordering, e.g., NSRDS–NBS–17, *Tables of Molecular Vibrational Frequencies, Part 3,* by T. Shimanouchi. If 100 copies or more of any publication are ordered, a discount of 25 percent is allowed by the Superintendent of Documents.

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tries, payments for documents must cover the postage. Therefore one-fourth of the price of the publication should be added for postage.

NSRDS Publication Summary Amended

This list amends the Publication Summary, which last appeared in the December TNB.

A. Publications Issued in the NSRDS Series:

1. Moore, C. E., Selected Tables of Atomic Spectra, Atomic Energy Levels and Multiplet Tables, Si I, NSRDS-NBS-3, Section 2 (20 cents).[1]

2. Trotman-Dickenson, A.F., and Milne, G. S., Tables of Bimolecular Gas Reactions, NSRDS-NBS-9 ($2).[1]

3. Ho, C. Y., Powell, R. W., and Liley, P. E., Thermal Conductivity of Selected Materials, Part 2, NSRDS-NBS-16 ($2).[1]

4. Shimanouchi, T., Tables of Molecular Vibrational Frequencies, Part 3, NSRDS-NBS-17 (30 cents).[1]

B. Other NBS Compilations of Data:

1. Wagman, D. D., Evans, W. H., Parker, V. B., Halow, I., Bailey, S. M., and Schumm, R. H., Selected Values of Chemical Thermodynamic Properties, Tables for the First Thirty-Four Elements in the Standard Order of Arrangement, NBS Tech. Note 270-3 ($1.25).[1]

2. Moiseiwitch, B. L., and Smith, S. J., Electron Impact Excitation of Atoms, *Rev. Mod. Phys.* **40**, No. 4 (Apr. 1968).

3. Krauss, M., Compendium of *ab initio* Calculations of Molecular Energies and Properties, NBS Tech. Note 438 (70 cents).[1]

C. Nondata Publications from NSRDS Related Projects:

1. Glennon, B. M., and Wiese, W. L., Bibliography on Atomic Transition Probabilities, NBS Misc. Publ. 278—Supplement (30 cents).[1]

2. International Directory of Workers in the Field of Atomic and Molecular Collisions, May 1967, ORNL-AMPIC-5 (June 1967).[2]

3. Bibliography of Atomic and Molecular Processes for July-December 1966, ORNL-AMPIC-8 (Oct. 1967).[2]

4. Bibliography of Atomic and Molecular Processes for January-June 1967, ORNL-AMPIC-9.[2]

5. Photonuclear Data Index, NBS Misc. Publ. 277—Supplement 1 (45 cents).[1]

[1] Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for the price indicated.
[2] Available from the Atomic and Molecular Processes Information Center, Oak Ridge National Laboratory, P.O. Box Y, Oak Ridge, Tenn. 37831.

PACKAGING *continued*

facilitate a sound marketing judgment. For example, information identifying the manufacturer and the net quantity of the contents must be uniformly and prominently displayed.

FPLA gives regulatory authority on package labeling to the Secretary of Health, Education, and Welfare (HEW) and the Federal Trade Commission (FTC), but the Secretary of Commerce is responsible for transmitting labeling regulations to State authorities and must aid State and Federal agencies in promoting uniform labeling. Working toward this objective, NBS has conducted an active program of liaison with State and local weights and measures officials and representatives of other agencies of the Federal Government. The weights and measures laws of each of the States have also been analyzed for compatibility with the terms of FPLA, and appropriate amendments recommended. In most cases necessary amendments have been enacted by the State legislatures.

NBS staff members have visited 45 States to discuss with State and local officials the terms of the new statute and its effect upon the enforcement programs of the States. These visits have encouraged cooperation from State officials. Such cooperation, of course, is vital to the collection of marketing data on packages and to the determination of adherence to voluntary Product Standards issued under the terms of the statute.

BRANSCOMB RECEIVES AWARD

■ On April 27, 1968, Lewis M. Branscomb, Chairman of the NBS-Colorado University Joint Institute for Laboratory Astrophysics and Chief of the NBS Laboratory Astrophysics Division, Boulder, Colo., received the Career Service Award of the National Civil Service League, one of the highest honors available to an employee of the Federal Government. The award was established to honor the unsung heroes of the Federal service, inspire better performance by their colleagues, and encourage talented young people to make careers in government—whether national, state, or local.

The awards were presented to the ten recipients at a banquet and dance held in Washington, D.C. Each winner received $1000, an NCSL citation, and an engraved gold watch.

Dr. Branscomb was honored by the League as a physicist-administrator who "works to smooth interaction of technology and our society." They note that "He has helped evaluate and plan the Nation's scientific program and policy, particularly with relation to national defense, the space effort, and atomic energy."

The National Civil Service League is a nonpartisan, nonprofit citizens' group that was organized in 1881 to promote efficiency, economy, and quality in government management.

CONFERENCE & PUBLICATION Briefs

NBS TO HOST ACTIVATION ANALYSIS CONFERENCE

The third international conference in the series "Modern Trends in Activation Analysis" will be held at the NBS Gaithersburg (Md.) laboratories October 7–11, 1968. The 1968 program is jointly sponsored by the National Bureau of Standards, U.S. Atomic Energy Commission, International Atomic Energy Agency, and EURISOTOP of the European Communities Commission. The Conference will concentrate on recent developments in all areas of nuclear activation analysis. Cochairmen of this conference are James R. DeVoe and Philip D. LaFleur of NBS.

Each day of the symposium will be devoted to a specific area of activation analysis. These areas include nuclear reactions, applications, radiochemical separation, instrumentation and data handling, and computation of results. For purposes of orientation, each morning an invited speaker will review a major field of activation analysis, evaluate the state of the art, and predict the future direction of progress in that field.

The orientation lectures are to be followed by two concurrent sessions where synopses of accepted papers will be presented. After the presentations, a plenary panel will discuss each session subject. This will allow all attendees to participate in the discussions of both sessions.

Subjects for the conference were selected to provide guidance for future activities in the field of activation analysis. Sessions will therefore be held on topics like pollution control even though activity in this field has scarcely begun. Additional topics to be discussed include biomedical research, cosmochemical research, special techniques, radiochemistry of groups of elements, nuclear instrumentation, and accuracy and precision. Several other sessions will cover specific types of analyses such as photon activation analysis.

Particular emphasis will be placed on new ideas in the field of activation analysis and extra time will be allotted for their presentation. Condensations of papers will be preprinted and made available at the beginning of the symposium. The symposium proceedings will include the condensations of the contributed papers, the complete invited papers, and synopses of the panel discussions.

Participants are invited to visit the Bureau's new 100-MeV linear electron accelerator and its 18-megawatt research reactor.

Anyone desiring to present papers or to have more information about the symposium should write to Dr. James R. DeVoe, Rm. A361, Chemistry Bldg., National Bureau of Standards, Washington, D.C. 20234.

MAN AND HIS SHELTER

A Conference Series to Explore All Aspects of Building Technology and Its Relationship to the Needs of Man

The NBS Institute for Applied Technology has announced plans to sponsor a series of interdisciplinary conferences entitled "Man and His Shelter." The conferences will cover the entire range of problems encountered in sheltering man at home, at work, and at play. Designed to bring together architects, engineers, builders, contractors, manufacturers, specification writers, psychologists, sociologists, and others in the building industry, the series should provide a comprehensive view of the problems facing the industry as a whole.

The Institute's Building Research Division, with its multidisciplinary experience in this field, will act as host and coordinator of the conference series.

The first of these conferences, Performance of Buildings—Concept and Measurement, will be held on September 23–25, 1968, at the Bureau's Gaithersburg, Md., site and will concern the performance concept in building. It will provide the various segments of the industry an opportunity to exchange ideas and should help to eliminate the confusion surrounding the term "performance concept." The program will be composed of talks by industry spokesmen experienced in the performance field and by NBS staff members engaged in performance-related projects. One such project is a joint NBS–HUD project on performance standards for low-cost housing.

Tentative topics for subsequent conferences include Modular Coordination; Cost and Evaluative Systems; Fire Research and Safety; Materials—New Ideas and Approaches; User Needs; Building Codes.

For further information and registration forms, write to:

Dr. W. W. Walton
Rm. B268, Building Research
National Bureau of Standards
Washington, D.C. 20234

SCHEDULED NBS-SPONSORED CONFERENCES

Each year NBS sponsors a number of conferences covering a broad range of topics in science and technology. The conferences listed below are either sponsored or cosponsored by NBS and will be held at the Bureau's Gaithersburg, Maryland, facility unless otherwise indicated. These conferences are open to all interested persons unless specifically noted. For further information, address the person indicated below in care of Special Activities

Section, Rm. A600, Administration Bldg., National Bureau of Standards, Washington, D.C. 20234.

National Conference on Weights and Measures. June 17–21. Contact: M. W. Jensen (NBS Manager of Engineering Standards). To be held at the Sheraton-Park Hotel, Washington, D.C.

Conference on the Structural Properties of Hydroxyapatite and Related Compounds. Sept. 11–13. Contact: W. E. Brown (NBS Polymers Division).

Measurements Technology. Sept. 17–18. Cosponsor: Scientific Apparatus Makers Association. Contact: G. E. Lawrence (SAMA).

Conference on Thermal Expansion. Sept. 18–20. Cosponsor: Westinghouse Astronuclear Laboratory. Contact: R. K. Kirby (NBS Metrology Division).

Performance of Buildings—Concept and Measurement. Sept. 23–25. Contact: W. W. Walton (NBS Building Research Division).

1968 International Conference on Modern Trends in Activation Analysis. Oct. 7–11. Cosponsors: U.S. AEC; International Atomic Energy Agency; EURISOTOP. Contact: P. D. LaFleur (NBS Analytical Chemistry Division).

Standards for High Pressure Research. Oct. 14–18. Contact: C. W. Beckett (NBS Heat Division).

Seminar on Durability of Insulating Glass. Nov. 14–15. Cosponsor: ASTM Committee E–6 on Methods of Testing and Building Construction. Contact: Henry Robinson (NBS Building Research Division).

Workshop on Mass Spectrometry. Nov. 18–19. Contact: A. J. Ahearn (NBS Analytical Chemistry Division).

BUILDING SCIENCE PUBLICATIONS

The Bureau has issued three more publications in its Building Science Series (BSS).

Fire Resistance of Steel Deck Floor Assemblies,[1] BSS–11, 22 pages (25 cents), by H. Shoub and S. H. Ingberg, describes tests by which the fire endurance performance of steel deck floors under a design load was determined. The work was a cooperative effort of NBS and the American Institute of Steel Construction.

Although the work reported here was performed between 1931 and 1933, much of the data are still pertinent. At the time of the tests, the apparent promising future for steel deck floor systems failed to materialize because of the development of other light-weight steel products, such as open-web joists and light-gage decking. However, the performance of the ceiling structures and floor toppings under test is of considerable interest in the design of floor assemblies now in use. Also, the burnout trials are apparently the only full-scale laboratory tests conducted in which heat transfer to the room below was measured.

Performance of Square-Edged Orifices and Orifice-Target Combinations as Air Mixers,[1] BSS–12, 11 pages (15 cents), by T. K. Faison, Jr., J. C. Davis, and P. R. Achenbach, describes apparatus and prototype mixing devices used at NBS to produce a uniform temperature in an air stream cross section. Two methods of air mixing, which have been used in laboratories for a number of years, were investigated—the square-edged orifice and the orifice in combination with a target.

The publication also contains graphic material that illustrates how the orifice and orifice-target combinations perform as mixing devices under selected conditions.

Shrinkage and Creep in Prestressed Concrete, [1] BSS–13, 12 pages (15 cents), by Perry H. Petersen and David Watstein, reports on factors affecting the loss of prestress in prestressed concrete.

Although the advantages of prestressed concrete over conventional reinforced concrete are well known, some properties of prestressed concrete remain to be fully explored. One of these properties is the loss of prestress in pretensioned concrete elements in which steel wire or cable is prestressed beforehand and the concrete is placed around the steel and bonded to it.

The loss of prestress resulting from creep and shrinkage in concrete was investigated for concrete specimens made with normal (Type I) Portland cement and with high-early strength (Type III) Portland cement. Forty-nine sets of specimens were fabricated and tested, each set consisting of a prestressed specimen and an otherwise identical companion specimen without reinforcement.

The primary variables considered were (1) the relative humidity; (2) the age of concrete when prestressed; (3) the ratio of prestress to strength; and (4) the mass ratio factor. The length changes with time were observed at intervals up to an age of 500 days. These observations were made for concretes subjected to different levels of prestress, for concretes prestressed at different ages, and for the nonreinforced companion specimens.

DATA PUBLISHED ON MICROWAVE TUBES

A tabulation of the characteristics of microwave tubes has been published as NBS Handbook 104, *Tabulation of Data on Microwave Tubes,*[1] 152 pages ($1.25). Compiled by J. K. Moffitt, it was made possible by the up-to-date tabulation of microwave tubes that is maintained by the Electron Devices Data Service of the NBS Institute for Applied Technology. The new Handbook, an updated version of NBS Handbook 70, provides current information on microwave electron tubes that should be of interest to electronics engineers in this and other countries.

The data tabulation gives characteristics of each tube type and is organized into two major listings. The first is a numerical listing, in which the tubes are arranged by type number; and the second, a characteristic listing, in which the tubes are arranged by the kind of tube, and on the basis of minimum frequency and power output.

The tube data in this publication are given in an easily decipherable code and format which are adaptable to

continued

punched cards. The sources of information for the tabulation are manufacturers' handbooks and data sheets published up to April 1967. It includes microwave tubes of 44 manufacturers, 18 of them foreign.

COLORIMETRY

Because of the many advances in colorimetry in the last few years and the continuing demand for data in the field, NBS Monograph 104,[1] *Colorimetry* (24 pages, 35 cents), by I. Nimeroff, has been issued as an up-to-date revision of NBS Circular 478, which was published in 1950.

Defining color as a characteristic of light, the publication gives the basic principles of color measurement and covers the various methods of colorimetry—such as direct methods, and visual and photoelectric methods used when determining differences with material standards. In addition, some of the limitations of these methods are discussed.

Also included are a description of the reduction of spectrophotometric data to three chromaticity coordinates by using the three-function CIE standard observer system for colorimetry; a discussion of the most useful collections of material color standards; and an explanation of the most widely used one-dimensional color scales.

PROCEEDINGS OF THE OPERATIONS RESEARCH CONFERENCE

Operations research practitioners and users in the Federal Government met at an NBS-sponsored symposium to exchange information on topics of mutual concern. The report on this symposium appears as NBS Miscellaneous Publication 294,[1] *Operations Research—Proceedings of a Conference for Washington Area Government Agencies, April 20, 1966* (24 pages, 25 cents).

The Proceedings covers several aspects of operations research in the civilian sector of the Government, including improved communications among the civilian agencies. It also covers the Conference's look at the Planning, Programming, and Budgeting program's relation to systems analysis.

Reports of two of the three panel meetings are included. One panel reviewed special problems of operations research in civil agencies of government; the other, the broadening of the operations research competence of mid-careerists.

MECHANICAL PROPERTIES OF COPPER AND ITS ALLOYS

Over the past 60 years considerable data have been accumulated on the mechanical properties of copper and its alloys. NBS Monograph 101,[1] 161 pages ($2.75), compiled by R. P. Reed and R. P. Mikesell, is a thorough compilation of the literature data on copper and selected copper alloys.

Low-Temperature Mechanical Properties of Copper and Selected Copper Alloys—A Compilation from the Literature is divided into four sections: (1) average values of mechanical properties for quick reference; (2) mechanical properties data from all investigations; (3) tables classifying the investigations not included in the preceding; and (4) an alphabetical list of references.

In bringing out this publication, the authors were financially assisted by the International Copper Research Association (INCRA) and the Copper Development Association.

They were also assisted by INCRA in the selection of alloys. The publication includes data on pure copper plus some of the common solid solution copper alloys (copper-zinc, copper-nickel, copper-aluminum) and some age-hardened alloys (aluminum bronzes, copper-silicon, copper-zirconium).

[1] These publications are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for the price indicated.

PUBLICATIONS of the National Bureau of Standards*

PERIODICALS

Technical News Bulletin, Volume **52**, No. 5, May 1968, 15 cents. Annual subscription: Domestic, $1.50; foreign, $2.25. Available on a 1-, 2-, or 3-year subscription basis.

Journal of Research of the National Bureau of Standards

Section A. Physics and Chemistry. Issued six times a year. Annual subscription: Domestic, $5; foreign, $6. Single copy, $1.

Section B. Mathematical Sciences. Issued quarterly. Annual subscription: Domestic, $2.25; foreign, $2.75. Single copy, 75 cents.

Section C. Engineering and Instrumentation. Issued quarterly. Annual subscription: Domestic, $2.75; foreign, $3.50. Single copy, 75 cents.

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PUBLICATIONS IN OTHER JOURNALS

This column lists all publications by the NBS staff, as soon after issuance as practical. For completeness, earlier references not previously reported may be included from time to time.

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CLEARINGHOUSE BIBLIOGRAPHIC JOURNALS**

U.S. Government Research & Development Reports. Semimonthly journal of abstracts of R&D reports on U.S. Government-sponsored projects and U.S. Government-sponsored translations of foreign technical material. Annual subscription (24 issues): Domestic, $30; foreign, $37.50. Single copy, $3.

U.S. Government Research & Development Reports Index (formerly *Government-Wide Index to Federal Research & Development Reports*). Semimonthly index to preceding; arranged by subject, personal author, corporate author, contract number, and accession/report number. Annual subscription (24 issues): Domestic, $22; foreign, $27.50. Single copy, $3.

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